The Importance of Slab Edge & Balcony Thermal Bridges

Report # 4: Thermal Modeling Considerations for Balconies and Various Thermal Break Strategies

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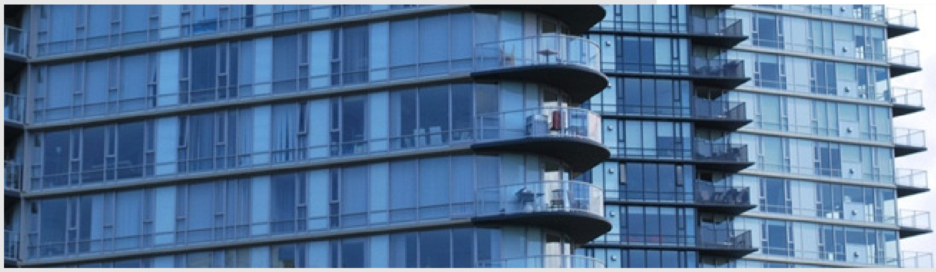

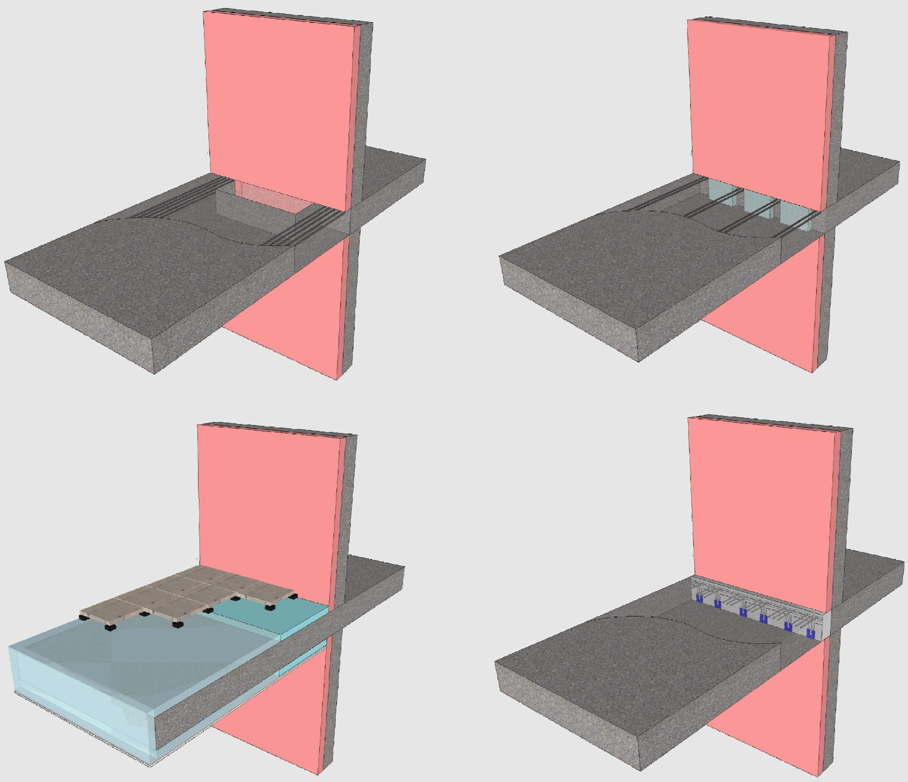

Prepared by

RDH Building Engineering Ltd.

Date

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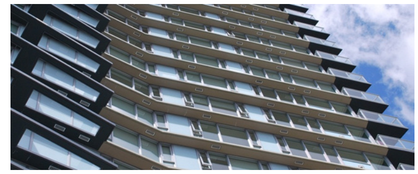
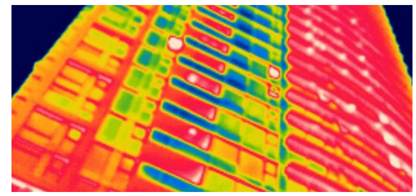
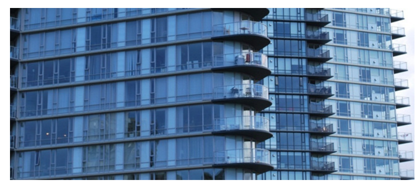


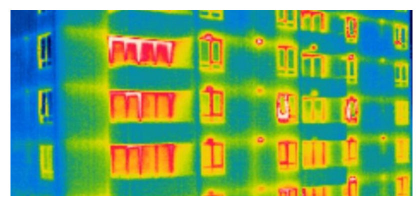
Thermal bridging occurs when heat flow bypasses the insulated elements of the building enclosure. Bridging occurs through structural components such as the studs/plates, framing, and cladding supports as well as the larger columns, shear walls, and exposed floor slab edges and protruding balconies. While thermal bridging occurs through the roofs, floors, and below-grade assemblies, it is often most pronounced in above-grade wall assemblies.



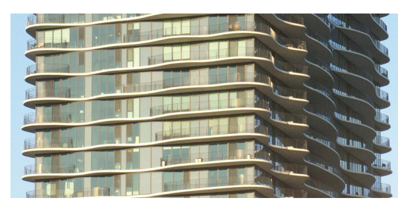
The heat flow through thermal bridges is significant and disproportionate to the overall enclosure area so that a seemingly well insulated building can often fail to meet energy code requirements, designer intent, or occupant expectations.



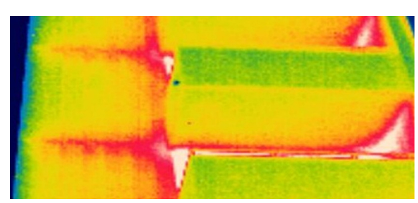
Windows are often seen as the largest thermal bridge in buildings, as the thermal performance is often quite low compared to the surrounding walls (i.e., an R-2 metal frame window within an R-20 insulated wall); however, exposed concrete slab edges and balconies can have almost as large of an influence having effective R-values of approximately R-1. After accounting for windows and doors, exposed concrete slab edges and balconies can account for the second greatest source of thermal bridging in a multi-storey building.



With a better understanding of the impacts of thermal bridging, the building industry has started to thermally improve building enclosures; for example, the use of exterior continuous insulation in walls is becoming more common.



Unfortunately the impact of floor slab edges and balconies is still often overlooked. At the same time, the architectural look of exposed slab edges and protruding balconies or “eyebrow” elements is becoming more common. Many designers believe that these relatively small elements have a negligible impact on the overall performance of the building or see them as an unavoidable compromise to achieve a certain appearance. Unfortunately, the impact of exposed slab edges and balconies is very significant, as this report will demonstrate. The relative impact of these elements also increases as more highly insulated walls are required by upcoming building code changes or sustainable building programs.

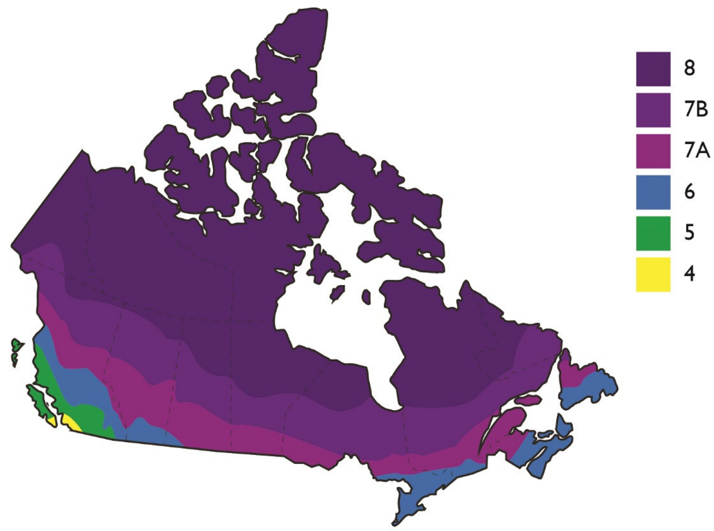


Fortunately, there are solutions available in the marketplace that help to minimize the thermal bridging impact at slab edges and balconies and allow for continued architectural design freedom under increasingly more stringent energy code requirements and occupant demands. This research report addresses the thermal control, comfort, energy, and cost impacts of exposed slab edges and balconies. It provides proven solutions and discussion of their implications with respect to these parameters.

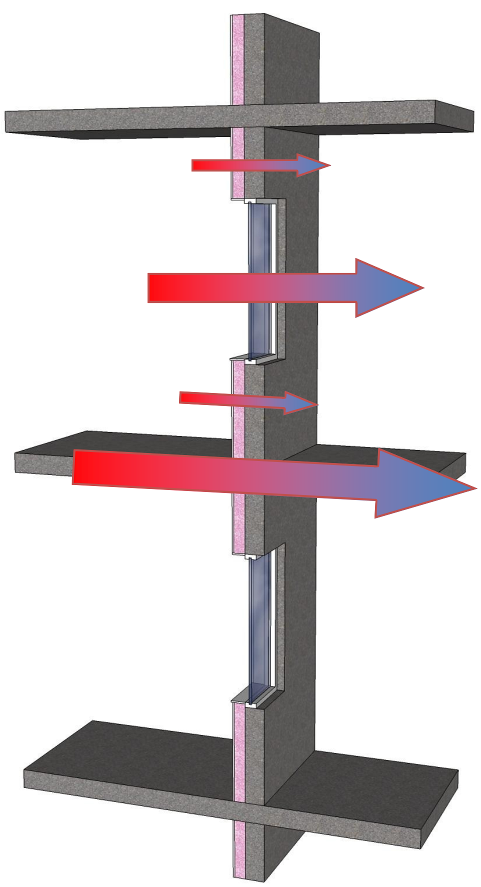
Exposed Slab Edge & Balcony Thermal Bridge Research Study

A research project was undertaken by RDH to quantify the thermal impact of exposed slab edges and balconies in mid- to high-rise residential buildings across climate zones in North America.

The impact of exposed slab edges and balconies on the effective wall R-values, indoor temperatures, and indoor thermal comfort was assessed. Space heating and cooling loads were also modeled in each climate zone for an archetypal multi-unit residential building to quantify the energy loss through exposed slab edges and balconies and to determine the space conditioning savings that could be achieved in typical scenarios when balcony and slab edge thermal break products are used.



Canadian climate map showing Climate Zones 4 through 8 per the 2011 NECB. ASHRAE 90.1-2010 uses a similar climate zone map; however, Zone 4 is bumped into Zone 5 due to differences in reference climate data between NECB and ASHRAE.



Thermal bridging paths through the enclosure of a concrete multi-storey building with balconies

The study addresses the following topics:

- Quantification of effective R-values, linear transmittance values (ψ), and indoor surface temperatures for various typical North American wall assemblies with and without exposed slab edges and balconies and with various balcony thermal break solutions.
- Assessment of various thermal modeling parameters including floor finishes, in-slab heating and balcony depth.
- Comparison of the effective thermal performance of several alternate balcony thermal break solutions, insulation strategies, and manufactured thermal break products.
- Comparison of the space conditioning (heating and cooling) energy consumption for multi-unit residential buildings with exposed slab edges and balconies and with the various thermal break solutions.

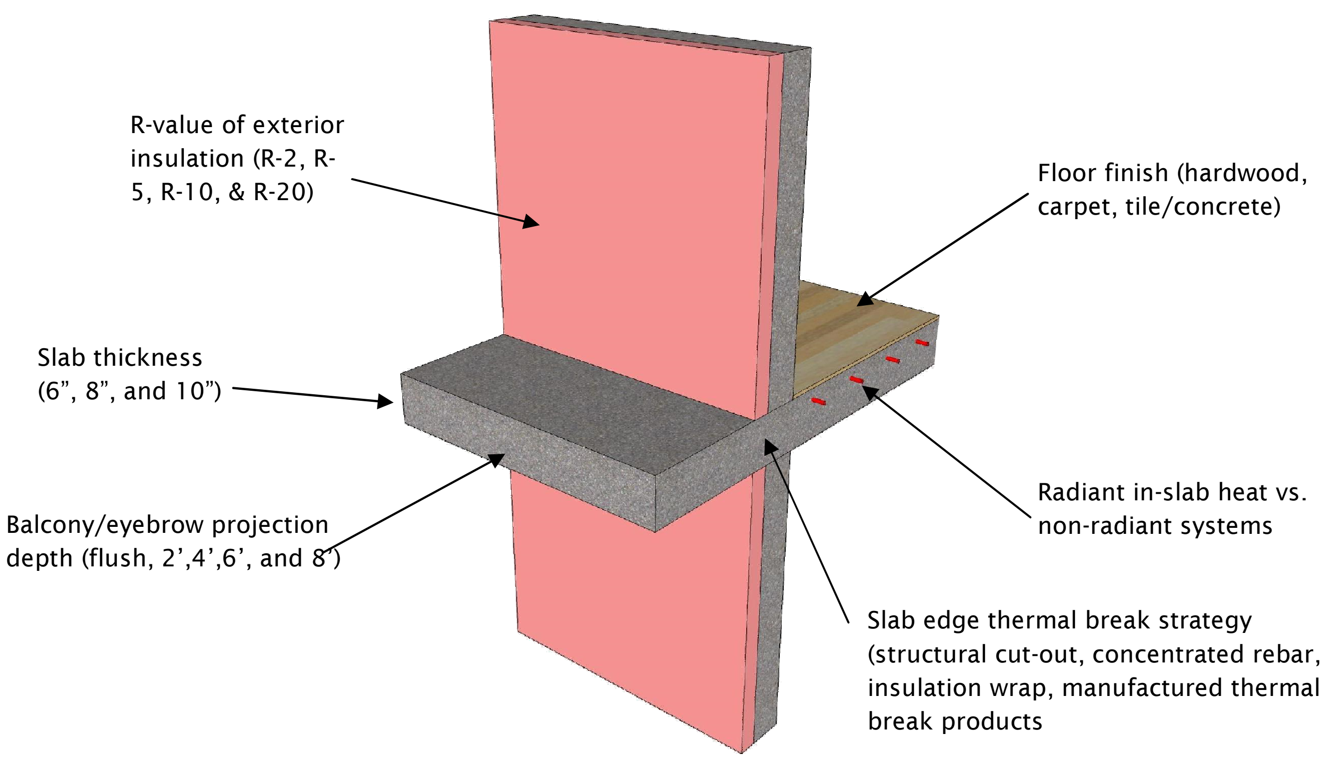
This Report #4 covers the assessment of various design parameters that impact the thermal modeling of balconies and slab edges, as well as thermal break solutions.

Thermal Impact Analysis of Balcony & Exposed Slab Edge Design Variables

A series of thermal simulations were performed to assess the impact of several design variables on the thermal performance and effective R-values for wall assemblies. The following design variables were considered and analyzed:

- Comparison of insulated slab edge, exposed slab edge, eyebrow projection (2' deep), and balcony projections (4', 6', and 8' deep)
- Impact of slab thickness (6", 8", and 10")
- Impact of floor finish (none/tile, carpet and underlay, hardwood and underlay)
- Impact of embedded radiant tubes within slab or slab topping
- Comparison of the following balcony thermal break solutions or products:
    - Structural cut-outs with and without insulation
    - Concentrated rebar with and without insulation
    - Balcony insulation wraps (varying coverage)
    - Manufactured balcony thermal break with a range of conductivities (R-values)

These design variables were analyzed with four simplified exterior insulated concrete wall R-value scenarios representative of different effective insulation strategies (R-2, R-5, R-10, and R-20). This was done to demonstrate the relative importance of each variable within a wide range of possible insulation strategies. While energy code R-value requirements are in the R-10 to R-20 range, and possibly higher for "green" buildings, many buildings are still constructed with relatively poor thermally performing walls in the R-2 to R-5 range. The base thermal model for this analysis is shown below with the variables that were assessed.



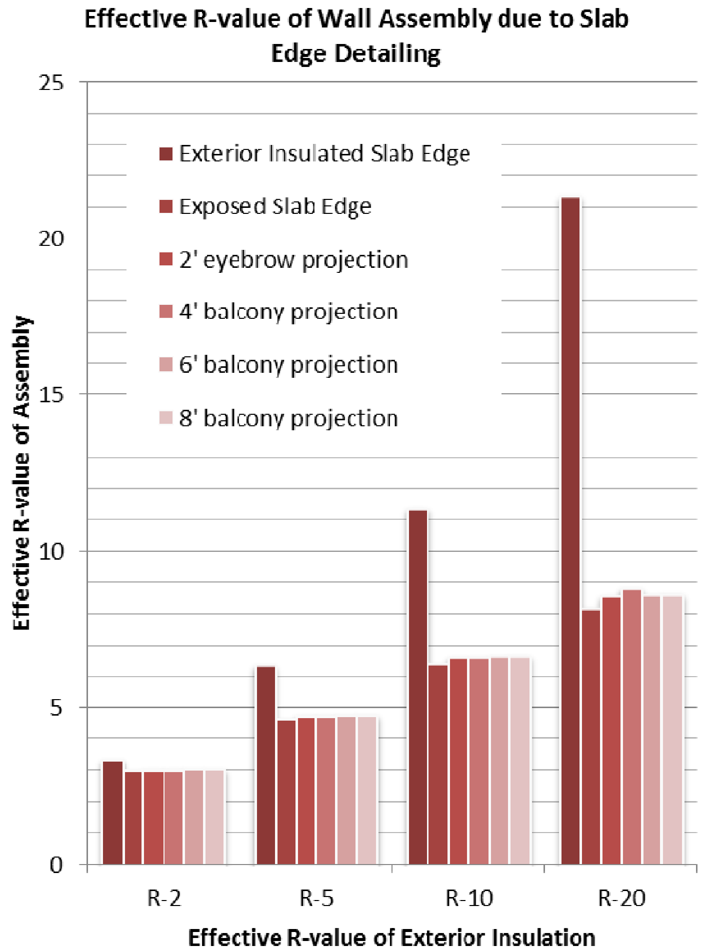
R-Value Impact of Exposed Slab Edges & Balconies

The first analysis assesses the thermal and energy impact of the slab edge detailing on the overall effective R-value of a floor-to-floor 8'-8" high wall section. Four wall exterior insulation cases are simulated including effective R-2, R-5, R-10, and R-20 over a 6" concrete wall backup.

The results in the adjacent chart compare the effective R-value of the whole wall assembly as the result of exposing the slab edge through the insulation and with varying projection depth.

As shown for the exterior insulated wall case, the exposed slab edge has a profound impact on the overall R-value of the wall assembly. This impact ranges from an R-value reduction of 11% to 62% where the adjacent wall has R-2 to R-20 of effective exterior insulation respectively.

The results also demonstrate that once the slab edge is exposed to the exterior (as is common in interior insulated wall assemblies) that the effective R-value is already significantly reduced—and that the addition of a 2' eyebrow or 4'-8' balcony does not reduce it further. In fact, the extra concrete on the exterior actually provides a very small amount of "insulation" to the system, resulting in slightly higher effective R-values in some cases.



	Effective Assembly R-Value with Slab Edge Detail & Percent Reduction from Insulated			
Slab Edge Detail/Insulation R-Value	R-2 Wall R-value	R-5 Wall R-value	R-10 Wall R-value	R-20 Wall R-value
Exterior-Insulated Slab Edge	3.4	6.4	11.4	21.4
Exposed Slab Edge	3.0	4.7	6.4	8.2
	11%	*27%*	*44%*	*62%*
2' Eyebrow Projection	3.0	4.8	6.6	8.6
	10%	*25%*	*42%*	*60%*
4' Balcony Projection	3.0	4.8	6.6	8.8
	10%	*25%*	*42%*	*59%*
6' Balcony Projection	3.0	4.8	6.6	8.6
	10%	*25%*	*42%*	*60%*
8' Balcony Projection	3.0	4.8	6.6	8.6
	10%	*25%*	*42%*	*60%*

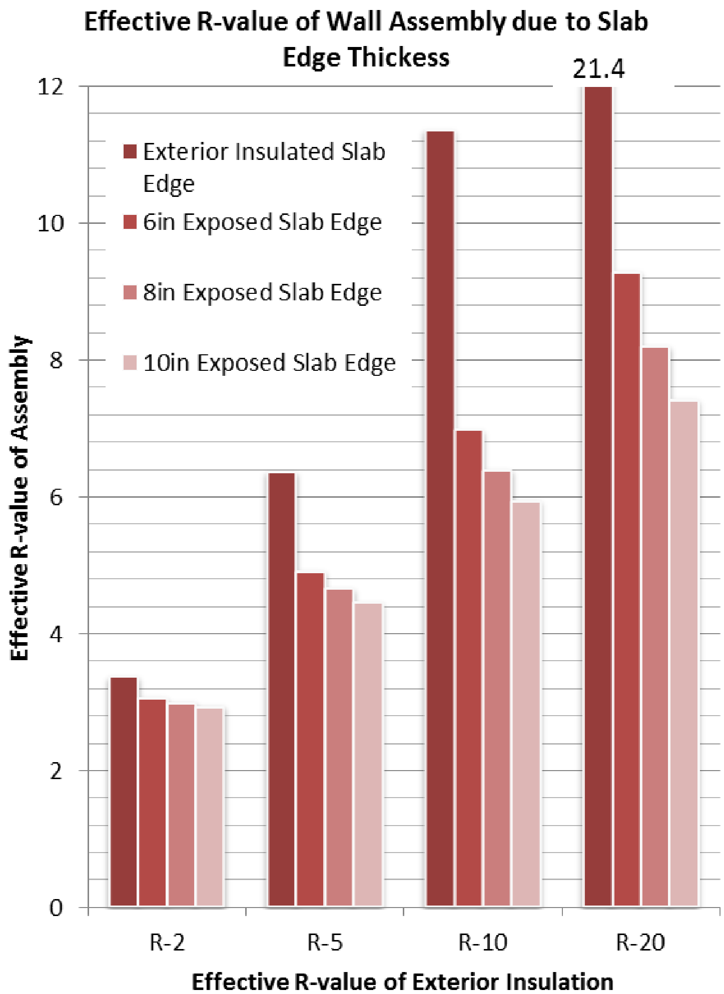
R-Value Impact of Slab Edge Thickness

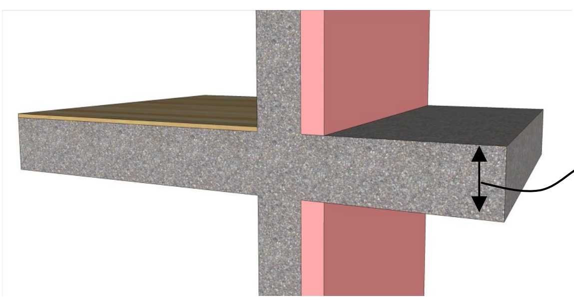
The second analysis assesses the impact of the slab thickness (from 6" to 10") on the overall effective R-value of a floor-to-floor 8'-8" tall wall section. Four wall cases are simulated including effective exterior insulation levels of R-2, R-5, R-10, and R-20 installed over a 6" concrete wall backup. Data is provided for the exposed slab edge scenario only, as the results for a protruding eyebrow or balcony would be very similar as previously demonstrated.

The results in the adjacent chart plot compare the effective R-value of the whole wall assembly as the result of just the slab edge thickness.

As shown, slab edge thickness has a fairly important impact on the whole-wall R-value even though the increased thickness may not appear significant. This is due to the increased area weight of the uninsulated slab portion in relation to the insulated wall.

This impact of slab edge thickness ranges from a total reduction of 9% to 14% for the R-2 wall case and 56% to 64% for the R-20 wall case.





Slab thickness matters - and the influence is greater with higher R-value walls.

	Effective Assembly R-Value with Slab Edge Detail & Percent Reduction from Insulated			
Slab Edge Detail/Insulation R-Value	**R-2 Wall R-Value**	**R-5 Wall R-Value**	**R-10 Wall R-Value**	**R-20 Wall R-Value**
Exterior-Insulated Slab Edge	3.4	6.4	11.4	21.4
6" Exposed Slab Edge	3.1	4.9	7.0	9.3
	9%	*23%*	*39%*	*56%*
8" Exposed Slab Edge	3.0	4.7	6.4	8.2
	11%	*27%*	*44%*	*62%*
10" Exposed Slab Edge	2.9	4.5	6.0	7.4
	13%	*30%*	*48%*	*65%*

R-value Impact of Interior Floor Finish & Radiant In-floor Heat

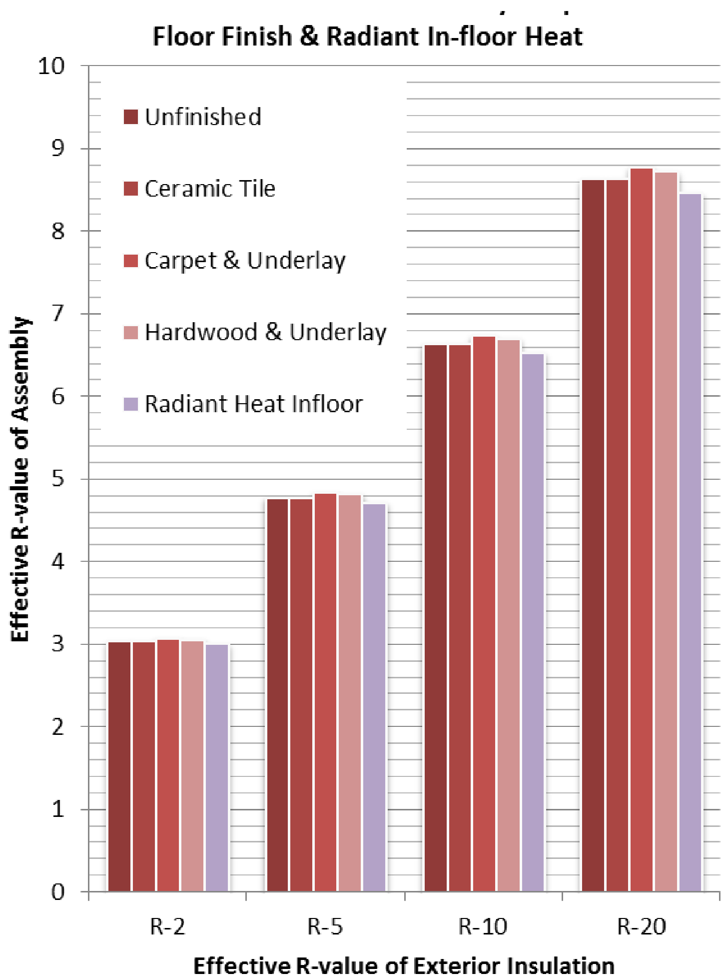
The third analysis assesses the thermal impact of the interior floor finish on the overall effective R-value of a floor to floor 8'-8" tall wall section. The impact of radiant in-floor heating on R-value is also included with these floor finish results.

Four wall cases are simulated including effective exterior insulation levels of R-2, R-5, R-10 and R-20 installed over a 6" concrete wall backup. Data is provided for the 6' balcony scenario only as the results for an exposed slab edge, eyebrow or other depth of balcony would be very similar as previously demonstrated. All cases except for the in-floor radiant heat case assume an air-source heating system (i.e. heat pump, electric resistance baseboard, forced air etc.). Radiant heating assumes unfinished or ceramic tile floor.

The results in the adjacent chart plot compare the effective R-value of the whole wall assembly with different interior floor materials. The ceiling is exposed concrete, as is typical for most condominiums near the exterior walls.

As shown, the interior floor finish has a negligible effect on the R-value of the wall assembly at a balcony (less than 1%).

The use of in-floor radiant heating vs. other air source heating systems has only a small reduction on the R-value of the all assembly (~1%). This results from the increased surface transfer from this warmer concrete slab.

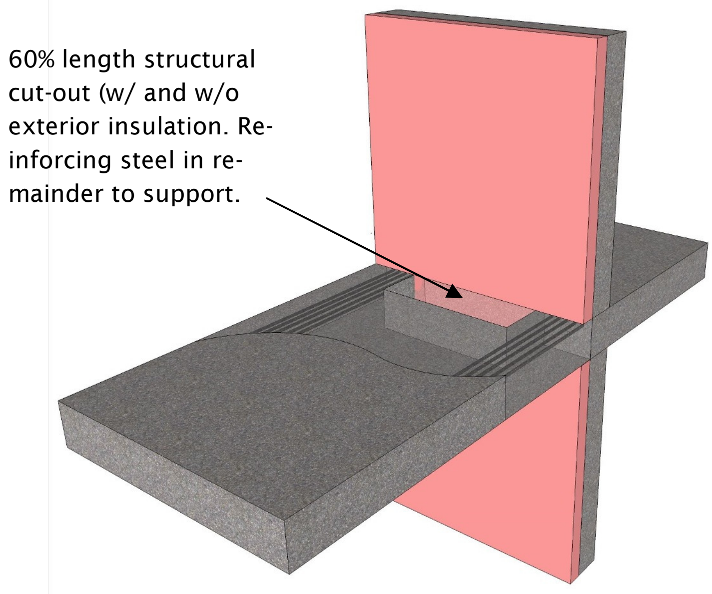


	Effective Assembly R-value with Slab Edge Detail & Percent Improvement from Unfinished Concrete Floor			
Slab Edge Detail/Insulation R-value	R-2 Wall R-value	R-5 Wall R-value	R-10 Wall R-value	R-20 Wall R-value
Unfinished Floor	3.0	4.8	6.6	8.6
Ceramic Tile	3.0	4.8	6.6	8.6
	0.0%	*0.0%*	*0.0%*	*0.0%*
Carpet & Underlay	3.1	4.8	6.7	8.8
	1.1%	*1.0%*	*0.9%*	*0.7%*
Engineered Wood/Hardwood & Underlay	3.1	4.8	6.7	8.7
	0.7%	*0.6%*	*0.6%*	*0.4%*
Radiant In-floor Heating System	3.0	4.7	6.5	8.5
	-0.9%	*-1.0%*	*-0.9%*	*-0.8%*

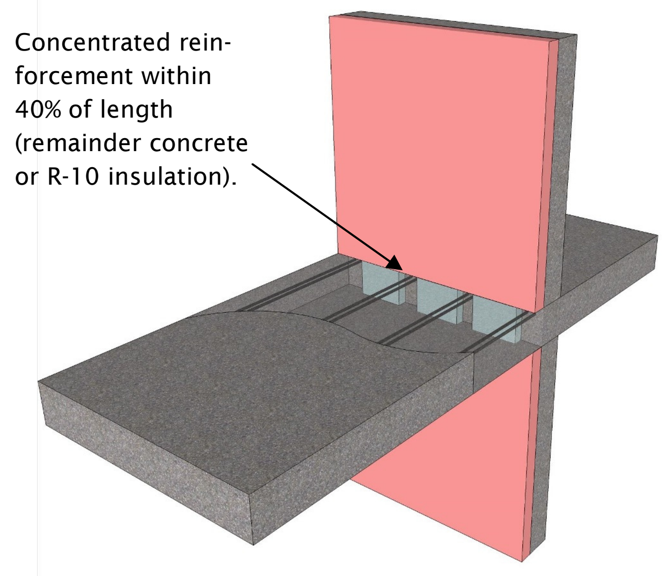
R-Value Comparison of Various Balcony Thermal Break Solutions & Products

A series of thermal simulations were performed to determine the effective R-value of wall assemblies with the following balcony thermal break solutions or products. Construction costs for each of the products and a generic material and installation cost per length of exposed balcony are also provided.

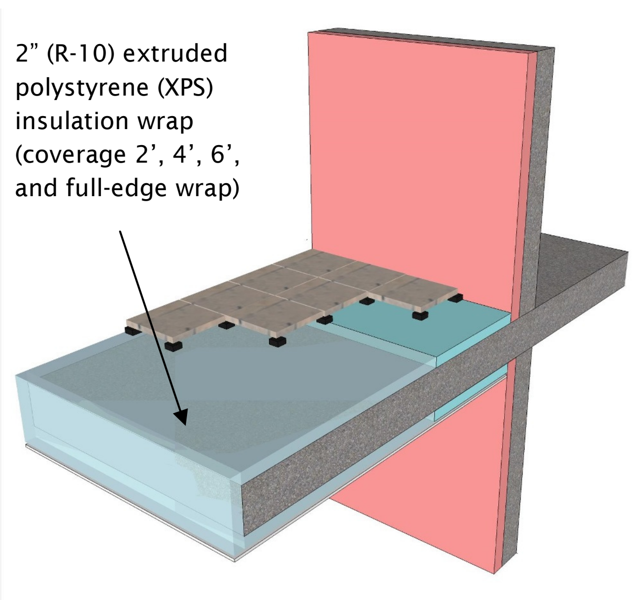
- Structural cut-outs with and without insulation
- Concentrated reinforcement with and without insulation
- Balcony insulation wraps (varying coverage)
- Manufactured balcony thermal break with range of conductivities



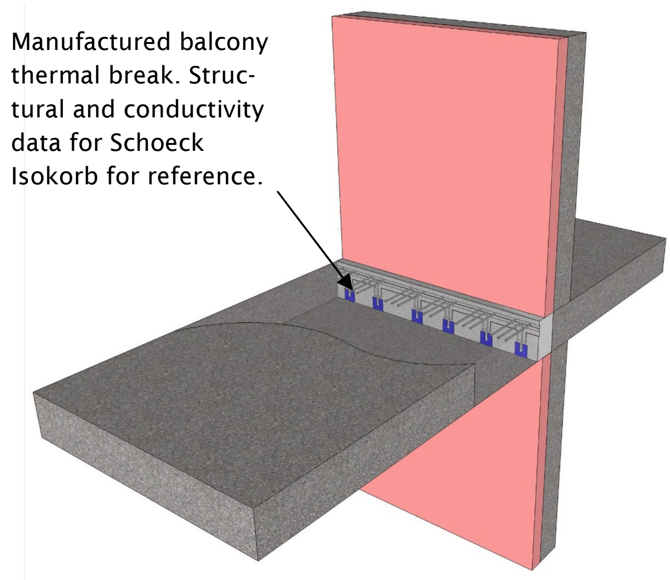
Structural cut-outs with beam reinforcement



Concentrated reinforcement with and without insulation



Insulation wrap (varying depth of coverage)

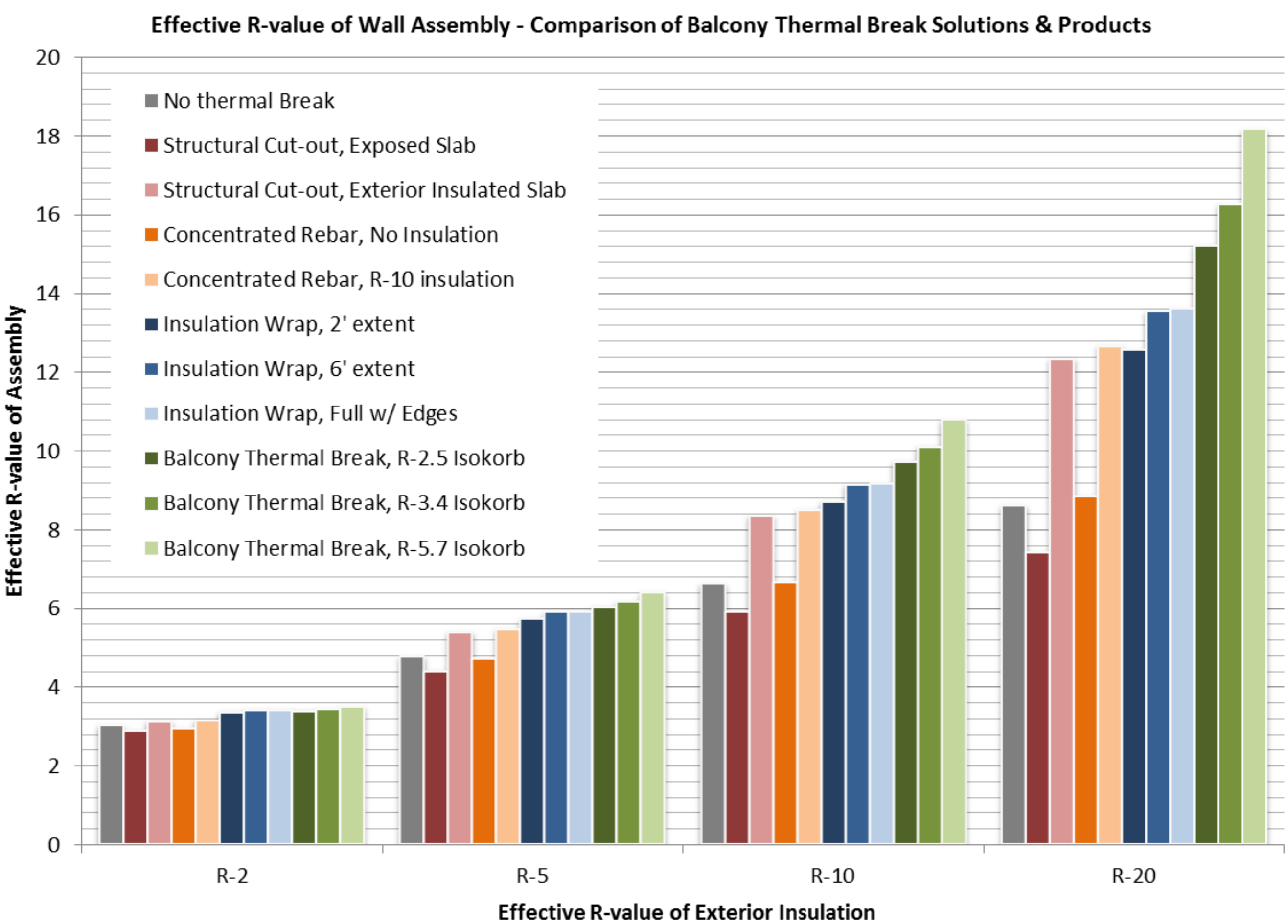


Manufactured purpose built balcony/slab edge thermal break

R-Value Comparison of Various Balcony Thermal Break Solutions & Products

The effective R-values for the various balcony thermal break solutions are shown in the following plot and also in a table in the appendix. The effective R-values presented here are for an 8'-8" tall wall with 8" slabs (8' floor-ceiling). Effective R-values with shorter walls will be lower due to the larger area impact of the slab edges. The four different balcony thermal break solutions/products modeled are as follows:

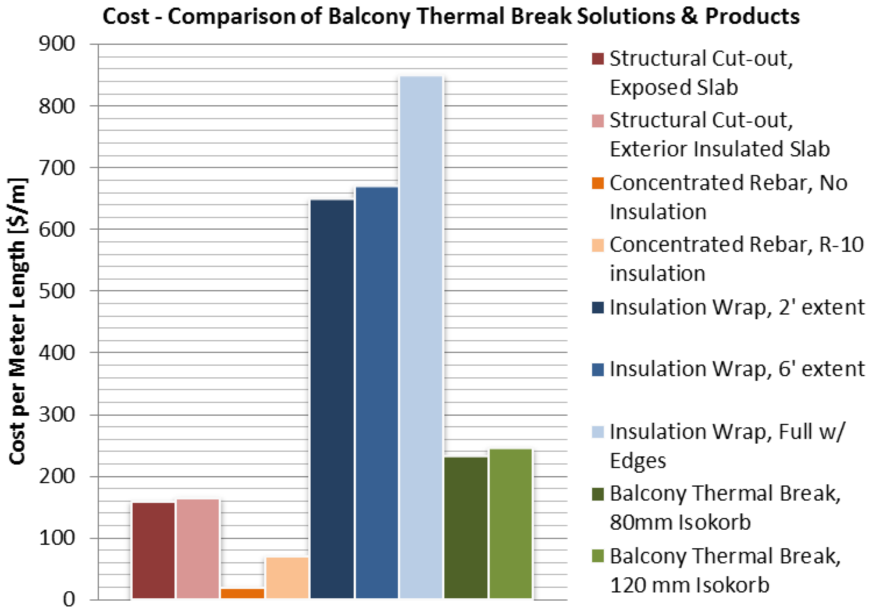
- **Structural Cut-out** - consists of a 12" slab cut-out where 60% of the slab is void space and the remainder 40% slab is beam reinforced to accommodate the entire slab load at the ends. This void would need to be protected, from a safety perspective, by railing or planter. Insulation may or may not be placed against the now-exposed slab edge. Insulation level to match wall insulation.
- **Concentrated Rebar** - consists of a scenario where all of the slab reinforcement is placed within an area 40% of the slab to create a series of small beams. In the 60% area between the reinforcement, the concrete is either insulated with 2" XPS (R-10) or left uninsulated.
- **Insulation Wrap** - consists of 2" XPS (R-10) wrapping in varying extents (from 2' to full) over the top and underside of the exposed balcony.
- **Balcony Thermal Break** - consists of a proprietary balcony thermal break with range of conductivities. Schoeck Isokorb products with a range from R-2.5 to R-5.7 are provided for their 2.5" (80 mm) and 4.75" (120 mm) deep thermal breaks.

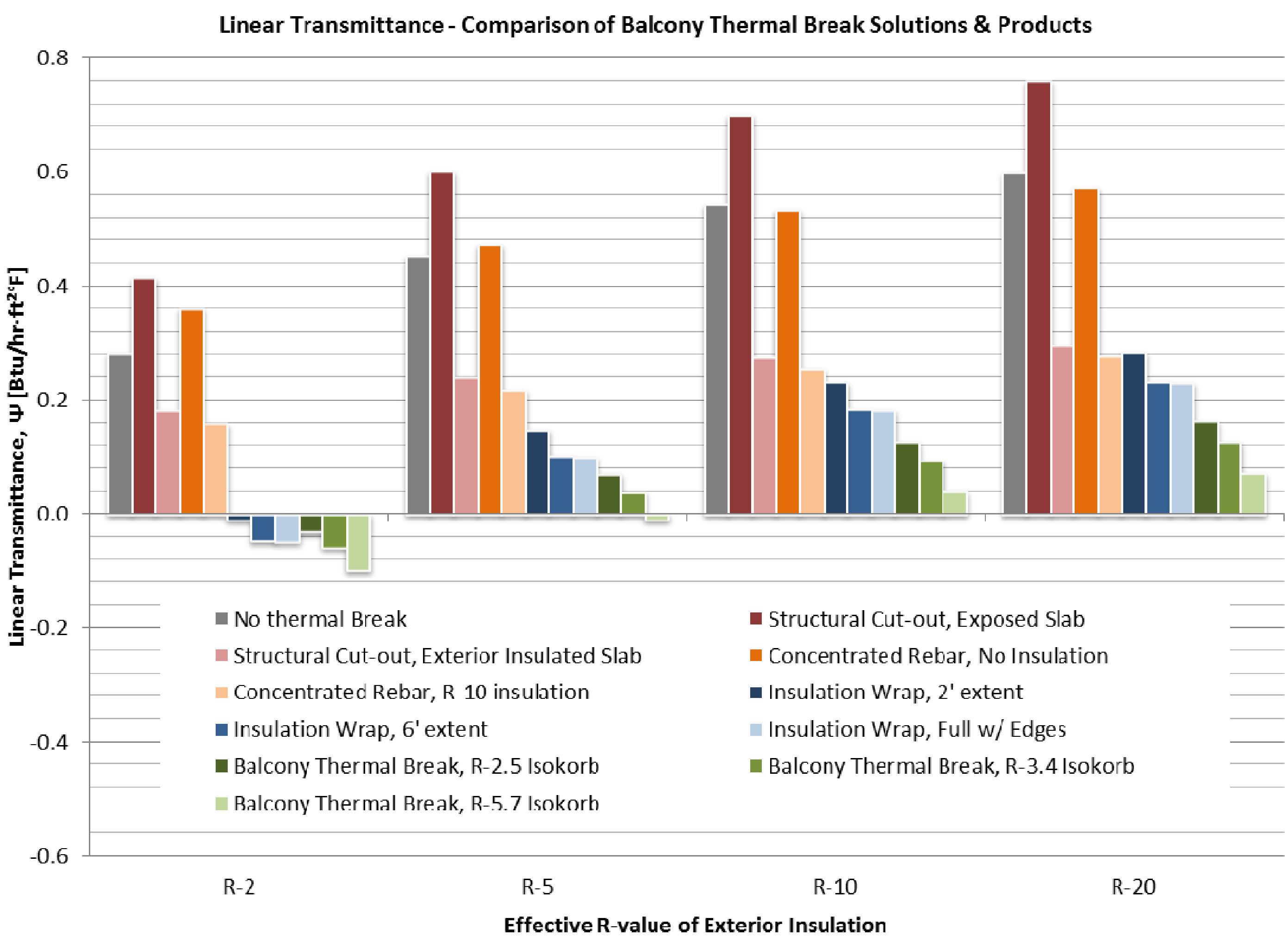


Linear Transmittance (ψ) and Cost for Various Balcony Thermal Break Solutions &

The linear transmittance values, ψ in units of Btu/hr·ft·˚F, is shown in the plot at the bottom of the page and also in a table in the appendix. These values are for the same arrangements as the calculated R-values on the preceding page. A negative thermal transmittance indicates that the balcony detail is more insulating than the wall without the balcony.

The approximate cost of each of the balcony arrangements based on fall 2012 construction and material costs in Vancouver, BC, are provided in the adjacent plot and additional detail is provided in a table in the appendix.





Conclusions

Thermal bridging in building enclosure systems often significantly reduces the effective R-value of wall assemblies. As industry moves toward higher R-value assemblies to meet more stringent building codes, energy standards, and occupant expectations, the reduction of this thermal bridging will be necessary. In many buildings, exposed slab edges, balconies, and eyebrows are one of the most significant thermal bridging elements.

A variety of solutions to reduce the effect of these thermal bridges are available with varying levels of practicality, performance, and cost. Some of these include, exterior insulation of slab edges, concentrating rebar attachment of balconies, wrapping balconies in rigid foam insulation, or using a manufactured system such as Schoeck Isokorb.

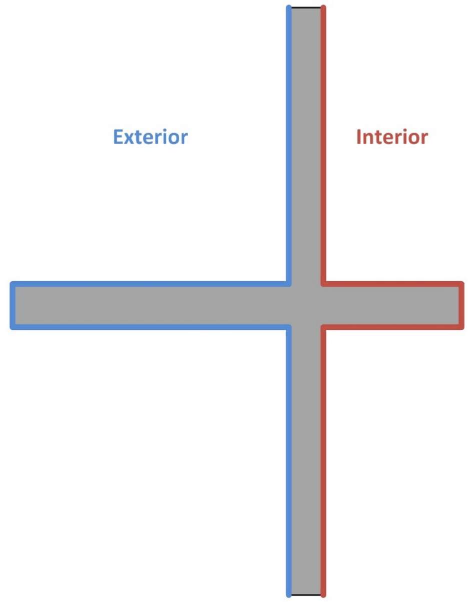
Use of these thermal break systems can significantly improve building enclosure thermal performance. The interior surface temperatures during winter conditions are increased, which reduces the potential for condensation and organic growth and improves thermal comfort for building occupants.

Overall, balcony slab edge thermal break systems provide architectural freedom to designers while maintaining the thermal performance characteristics of the building to reduce building energy consumption, improve thermal comfort, and meet increasingly stringent building code requirements. While these systems are currently uncommon in typical North American construction, as the industry develops, the incorporation of these systems in to building design will likely become increasingly commonplace.

Appendix: Thermal Modeling Inputs & Material Data

Thermal Modeling - Determination of R-Values, U-Values, and Linear Transmittance

The effective R-values for several typical wall assemblies with varying insulation levels were calculated using the three-dimensional finite element thermal modeling software, Heat3. This program has been validated to ISO 10211 standards and is widely used by researchers and consultants to perform advanced thermal simulations to calculate 3D effective R-values of building enclosure assemblies and details. RDH has also performed in-house confirmation of the software results with published guarded hot-box laboratory and ASHRAE 90.1 thermal data.

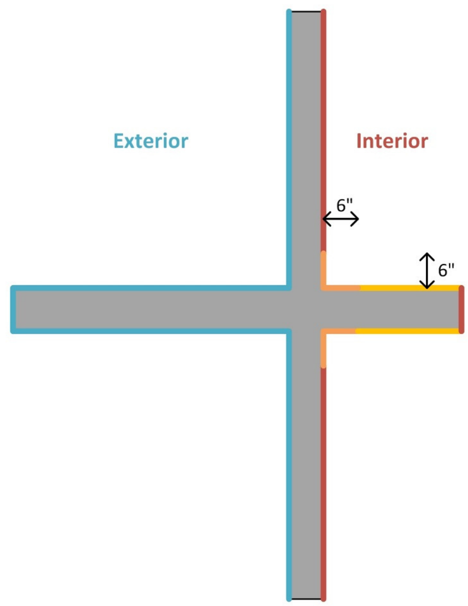


Boundary Conditions– R-value Models

To calculate R-values, a variety of different inputs were used within the Heat3 software. The models were created using the material properties provided on the following page and the boundary conditions as defined in the table below and illustrated in the image to the right. The exterior temperature was changed from the standard -17.8˚C to -10˚C to be more indicative of typical exterior conditions for the calculation of surface temperatures. Heat3 performs a finite difference calculation to determine the heat flow through the assembly, which is then divided by the temperature difference to determine U-value. The inverse of the U-value is the R-value.

Linear transmittance was calculated by first modeling the wall without a slab edge or balcony and then modelling it with the slab edge or balcony detail to determine their respective U-values. Then the formula below was used to calculated linear transmittance (ψ).

$$\Psi = \frac{(U_{Wall-WithSlabEdge} - U_{Wall-NoSlabEdge}) \cdot A_{wall}}{L_{slab}}$$

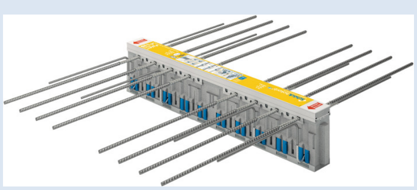


Boundary Conditions– Surface Temperature Models

Boundary Condition	Temperature (˚C)	Surface Film Coefficient (W/m²·K)
Exterior - R-Values	-17.8	23.0
Exterior - For Surface Temperatures	-10.0	23.0
Interior - R-Values	21.0	7.7
Interior - For Surface temperatures - Corner of Floor to Ceiling	21.0	4.0
Interior - For Surface Temperatures - Floor and Ceiling	21.0	6.0
Interior - For Surface Temperatures - Wall	21.0	7.7

Material Properties for Thermal Modeling

The following material properties were used within the Heat3 thermal models that were used to calculate effective R-values and temperatures to assess thermal comfort. These properties are based on published material data from numerous industry sources including ASHRAE, NRC, and product manufacturers.

Material Description		Thermal Conductivity, k (W/m·K)
Mineral Fiber or Fiberglass Insulation	R-3.0/inch Batts	0.048
	R-3.4/inch Batts	0.042
	R-3.6/inch Batts	0.040
	R-3.8/inch Batts	0.038
	R-4.2/inch Cavity Insulation	0.034
Extruded Polystyrene	R-5/inch Board	0.029
Expanded Polystyrene	R-4/inch standard board	0.030
	R-4.6/inch graphite enhanced	0.031
Closed Cell Sprayfoam	R-6/inch	0.024
Concrete (Temperature Steel Reinforced)		2.000
Concrete (Light Beam Reinforced)		3.000
Concrete (Heavy Beam Reinforced)		4.700
Steel	Galvanized Sheet (studs/girts)	62.000
	Stainless (ANSI 304)	14.300
	Rebar	50.000
Gypsum Sheathing/Drywall		0.160
Ventilated Airspace		0.450
Wood	Framing	0.140
	Plywood	0.110
Stucco (Cement-Lime)		0.720
Brick (North American Clay Brick)		0.450
Balcony/Slab Edge Thermal Break - Schoeck Isokorb, Range of Values for Standard Products. Actual project values will depend on structural requirements for balcony support 	R-2.5 (80 mm, 3.25”)	0.181
	R-3.4 (80 mm, 3.25”)	0.134
	R-3.4 (120 mm, 5”)	0.200
	R-4.5 (120 mm, 5”)	0.151
	R-5.0 (120 mm, 5”)	0.135
	R-5.7 (120 mm, 5”)	0.120

R-Value Comparison of Various Balcony Thermal Break Solutions & Products

The following table summarizes the effective R-values (ft^2·˚F·hr/Btu) of a wall assembly with a balcony and various solutions as discussed and shown in the plot on the previous page.

The percent improvement of each solution as compared to a scenario with no thermal break (standard practice) is also shown with each R-value. As demonstrated, some of the “solutions” are less effective than standard non-thermally broken practice, while the balcony thermal breaks perform quite well, resulting in high effective R-values.

Slab Edge Detail / Insulation R-Value	Effective Assembly R-Value (ft2·˚F·hr/Btu) with Slab Edge Detail & Percent Improvement from Non-thermally Broken Balcony (6’ deep)			
	R-2 Wall R-Value	R-5 Wall R-Value	R-10 Wall R-Value	R-20 Wall R-Value
No thermal Break, Exposed Slab	3.0	4.8	6.6	8.6
Structural Cut-out, Exposed Slab	2.9	4.4	5.9	7.4
	-4%	-8%	-11%	-14%
Structural Cut-out, Exterior Insulated Slab	3.1	5.4	8.4	12.4
	4%	13%	26%	43%
Concentrated Rebar, No Insulation	3.0	4.7	6.7	8.9
	-3%	-1%	1%	3%
Concentrated Rebar, R-10 insulation	3.2	5.5	8.5	12.7
	5%	15%	28%	47%
Insulation Wrap, 2' extent	3.4	5.7	8.7	12.6
	11%	20%	31%	46%
Insulation Wrap, 6' extent	3.4	5.9	9.2	13.6
	13%	24%	38%	57%
Insulation Wrap, Full w/ Edges	3.4	5.9	9.2	13.6
	13%	24%	38%	58%
Balcony Thermal Break, R-2.5 Isokorb	3.4	6.1	9.7	15.2
	12%	27%	47%	77%
Balcony Thermal Break, R-3.4 Isokorb	3.4	6.2	10.1	16.3
	14%	30%	53%	89%
Balcony Thermal Break, R-5.7 Isokorb	3.5	6.4	10.8	18.2
	15%	34%	63%	111%

For Comparison: Maximum Achievable R-Value with Exterior Insulated Slab Edge	3.4	6.4	11.4	21.4

Linear Transmittance (ψ) Value for Various Balcony Thermal Break Solutions & Prod-

The following table summarizes the effective linear transmittance values, ψ in units of Btu/hr·ft·˚F and W/m·˚K for the various balcony thermal break solutions. The concept of linear transmittance, while not commonly used in North American, is a useful metric to isolate the heat loss from specific linear details (like slab edges or corners) as compared to a base non-thermally bridged wall assembly. Where ψ value is negative, it means that the slab edge detail is better than a center of wall detail (due to the increased insulation level).

The conversion from ψ in IP units to SI units is to multiply the IP value by 1.73.

The conversion from U in IP to SI units is to multiply the IP value by 5.678.

Slab Edge Detail / Insulation R-Value	Linear Transmittance Value for Balcony Slab Edge Detail, ψ Btu/hr·ft·˚F & *W/m·˚K*			
	R-2 Wall R-Value	R-5 Wall R-Value	R-10 Wall R-Value	R-20 Wall R-Value
No thermal Break	0.281	0.452	0.543	0.599
	0.487	*0.783*	*0.940*	*1.036*
Structural Cut-out, Exposed Slab	0.415	0.600	0.699	0.760
	0.718	*1.039*	*1.210*	*1.315*
Structural Cut-out, Exterior-Insulated Slab	0.181	0.241	0.274	0.296
	0.313	*0.417*	*0.475*	*0.511*
Concentrated Rebar, No Insulation	0.361	0.473	0.534	0.572
	0.625	*0.818*	*0.924*	*0.990*
Concentrated Rebar, R-10 insulation	0.158	0.218	0.254	0.277
	0.274	*0.378*	*0.440*	*0.480*
Insulation Wrap, 2' extent	-0.009	0.147	0.231	0.283
	-0.016	*0.254*	*0.401*	*0.491*
Insulation Wrap, 6' extent	-0.047	0.102	0.183	0.233
	-0.082	*0.177*	*0.317*	*0.403*
Insulation Wrap, Full w/ Edges	-0.049	0.100	0.181	0.230
	-0.084	*0.174*	*0.314*	*0.399*
Balcony Thermal Break, R-2.5 Isokorb	-0.031	0.070	0.127	0.163
	-0.054	*0.121*	*0.220*	*0.282*
Balcony Thermal Break, R-3.4 Isokorb	-0.058	0.039	0.093	0.127
	-0.101	*0.067*	*0.161*	*0.220*
Balcony Thermal Break, R-5.7 Isokorb	-0.098	-0.010	0.040	0.071
	-0.169	*-0.017*	*0.069*	*0.123*

U values for clear wall, U_{wall} - no slab edge influence (Btu/hr·ft²·˚F & *W/m²·˚K*)	0.297	0.157	0.088	0.047
	1.687	*0.892*	*0.500*	*0.266*

Cost Comparison of Various Balcony Thermal Break Solutions & Products

The following table summarizes the estimated costs for the various balcony thermal break strategies broken down to a per meter of balcony cost. The costing analysis assumes a 6' deep balcony.

Slab Edge Detail / Costing	Thermal Effective-ness	Cost Estimate to Supply & Install Slab Edge Thermal Break at Balcony Based on Fall 2012 Construction and Material Costs in Vancouver, BC			
		Notes/Assumptions	Material Cost ($/m)	Labour Cost ($/m)	Total Cost ($/m)
No thermal Break	**N/A**	Standard reinforced concrete	N/A	N/A	N/A
Structural Cut-out, Exposed Slab	**Worse**	Structural design, 60% length of balcony removed, 12" deep. Extra cladding/membrane. Cut-out protection railing or a planter to cover.	$60	$100	$160
Structural Cut-out, Exterior-Insulated Slab	**Moderate**	Structural design, Same as above but exterior insulation same depth as wall. Extra cladding/flashing, waterproofing etc. Cut-out protection railing or planter. to cover	$65	$100	$165
Concentrated Rebar, No Insulation	**Poor**	Structural design, same concrete and likely same steel. Nominal cost.	$10	$10	$20
Concentrated Rebar, R-10 Insulation	**Moderate**	Structural design, 2" XPS and fireproofing plates added in and supported during concrete pour, extra waterproofing/detailing at slab edge. Essentially a home-made Isokorb type product. Patent	$50	$20	$70
Insulation Wrap, 2' Extent	**Moderate**	Structural for pavers, 2" XPS for 24" plus some waterproofing, flashing, pavers and pedestals. Plus soffit fire protection/cladding. Plus 5" taller guardrails.	$280	$370	$650
Insulation Wrap, 4' Extent	**Moderate**	Structural for pavers, 2" XPS for 48" plus some waterproofing, flashing, pavers and pedestals. Plus soffit fire protection/cladding. Plus 5" taller guardrails.	$300	$360	$660
Insulation Wrap, 6' Extent	**Moderate**	Structural for pavers, 2" XPS for 72" plus some waterproofing, flashing, pavers and pedestals. Plus soffit fire protection/cladding. Plus 5" taller guardrails.	$320	$350	$670
Insulation Wrap, Full w/ Edges	**Moderate**	Structural for pavers, 2" XPS for 72" plus some waterproofing, flashing, pavers and pedestals. Plus soffit fire protection/cladding and cladding at fascia Plus 5" taller guardrails with extensions base fascia.	$440	$410	$850
Balcony Thermal Break, 80mm Isokorb Products (R-2.5 to R-3.5)	**High**	Structural design and cost depends on balcony cantilever depth and seismic requirements. Assuming Schoeck Isokorb 80mm here (k=0.181 to 0.129). Extra installation cost. Includes fire protec-	$190 to $212 delivered from Germany	$5	$195 to $217
Balcony Thermal Break, 120 mm Isokorb Products (R-3.5 to R-5.7)	**High**	Structural design and cost depends on balcony cantilever depth and seismic requirements. Assuming Schoeck Isokorb 120 mm here. (k=0.194 to 0.12) Extra installation cost. Includes fire pro-	$228 to $254 delivered from Germany	$5	$232 to $259